

APPLICATION SERIAL NO. 09/821,335

PATENT

EXHIBIT A

THE PRODUCTION OF THIN FILMS

In chapter 1 we saw how the subject could be said to begin with Fraunhofer preparing thin films by the chemical etching of glass and also by depositing from solution. These and similar methods have been used to some extent in optical thin-film work. Other techniques that, at different stages in the development of the subject, have been, and are still sometimes, employed include anodic oxidation of aluminium to form a protective coating, and spraying of material on to a surface either in solution or in the form of a substance that can be chemically converted into the desired material later. The substance itself is sometimes sprayed on, possibly after vaporisation in a hot flame. Polymerisation of monomers deposited on surfaces by condensation from solution is also used occasionally. There are many important processes used principally in other areas of thin-film technology, which can be classified as chemical vapour deposition, in which materials in vapour form react at a hot substrate surface to form thin layers of the desired material. The chemical reaction can be assisted by energy from an electric discharge, the term *plasma process* being applied. Modern thin-film optical filters are, however, almost entirely manufactured by vacuum deposition processes which can be classified as physical vapour deposition. In these processes the thin films condense from the vapour phase on to the surfaces to be coated which are held at temperatures somewhat lower than the solidification temperature of the films. In order to prevent undesirable reactions taking place in the vapour phase, the process is carried out in an evacuated chamber. The various techniques differ principally in the way in which the material is vaporised. Sputtering consists of bombarding the desired material with ions in a vacuum chamber so that molecules are ejected to collide with and stick to the substrate. It was discovered in the 19th century and is particularly useful for refractory materials. There are also some other ion-assisted processes that are currently under development and may emerge as useful optical thin-film deposition processes. A wide range of such thin-film deposition techniques is fully covered in a useful book by Vossen and Kern¹. As far as optical coatings are concerned, they tend to be used only in special cases, and the most common and most flexible process for optical coating is that known as vacuum evaporation or thermal evaporation in vacuum.

In thermal evaporation the vapour is produced simply by heating the material that is known as the evaporant. Because of the reduced pressure in the chamber the vapour is given off in an even stream, the molecules appearing to travel in straight lines so that any variation in the thickness of the film that is formed is smooth, and depends principally on the position and orientation of the substrate with respect to the vapour source. The properties of the film are broadly similar to those of the bulk material, although, as we shall see, there are important differences in the detailed microstructure. Precautions that have to be taken to ensure good film quality include scrupulous cleanliness of the

Production methods and the

substrate surface, near normal incidence (heating the substrate to temperature on the material) before commencing in a sealed chamber that is evacuated to 10^{-3} mb. The materials to be deposited are one of a number of possible techniques. The plant consists of the chamber to be coated, gauges, power supplies for sublimation, monitoring equipment for thickness during the process, substrate controls. Modern thin-film coating

In order to evaporate the material from a crucible and it must be heated in a number of ways of achieving this: a crucible of refractory metal that is passed through it. The crucibles are either end and are commonly referred to as boats which are insulated from the structure. The resistance of the boats is low and voltages, are required to heat them. To protect the sealing rings, Figure 9.3 shows a baseplate com



Figure 9.1(a) For descript

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